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ABSTRACT

This paper illuminates experiences related to introducing finite element methods (FEM) in mechanical and civil engineering courses at the University of Camaguey in Cuba and provides discussion on using FEM in postgraduate courses for industry engineers. Background information on the introduction of FEM in engineering teaching is focused on mechanical engineering and civil engineering. Links between FEM and other disciplines or subjects within the specialty are also outlined. Results suggest that: (1) universities should work together across national boundaries to develop and integrate FEM in the curriculum; (2) use of FEM can result in more efficient use of computational engineers; and (3) FEM should be employed more frequently in problem solving in engineering. (Contains a bibliography). (DDR)

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AN INTRODUCTION OF FINITE ELEMENT METHOD IN THE ENGINEERING TEACHING AT THE UNIVERSITY OF CAMAGÜEY

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Abstract

This work shows the experiences on FEM introduction in mechanical engineering and civil engineering courses at the University of Camagüey, and it gives some consideration about the programs in postgraduate FEM courses to industry engineers.

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Introduction

Finite element methods have become the most widely used technique in modern engineering stress analysis. Traditional techniques can satisfy only a range of conventional ways and specific load situations, but in engineering neither the ways nor the load situations are usually conventional, so the traditional techniques must be modified and applied situations for which they have not been designed, therefore the designer is forced to use security factors higher than necessary and this involves overdrawn components, because of excessive cross sections or high quality materials; and all this increases the production cost.

The foundations of finite element method (F.E.M) have been known since the XIX century, but on account of the mathematics and computation that is needed by the method, it began to be applied in a general way in the seventies of the present century.

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Finite element method is not limited to the field of structural analysis, they are equally applicable to continuum mechanics problems in general, including those of fluid mechanics and heat transfer.

The aim of the present paper is to analyse the F.E.M. introduction in the curriculum of civil and mechanical engineering, its present and future state, and some reflections about the teaching of F.E.M. in postgraduate courses.

Introduction of finite element methods in the engineering teaching

The great applications that the F.E.M. with its computational programs have in big and small industries and design offices of the countries where equipment and technologies are produced, have determined a world-wide ever-increasing necessity, of engineer widely dextrous in F.E.M., and for this reason it appears in university curricula in agreement with the necessities and demands of each university and country.

Nevertheless, in some developed countries, although its design technique is greatly based on F.E.M., it is not taught at the undergraduate level, so the engineers have to learn the method rudiments in postgraduate courses, or to manipulate the professional programs without a deep knowledge of the methods basis, and how to model using it.

In the universities where F.E.M. is taught, this is done in different ways.

- As an independent subject
- Inside subjects such as applied mechanics or mathematics
- As an optional subject

The situation that is confronted in the present world with its steady increase of scientific and technical information that must be assimilated, and the swiftness with which it becomes old - fashioned, makes it difficult to include new topics which satisfy the professional model general objectives and play a meaningful role in it.

All these elements have been kept in mind in the introduction in undergraduate and postgraduate courses of the teaching of F.E.M.

Experience in F.E.M. introduction in the civil and mechanical engineering specialities

Civil engineering

In this speciality the method is included in the subject Numerical Methods and Finite Element, within the Mathematics discipline.

The subject is divided in two big parts:

Part I.- Numerical methods

Part II.- Finite Element Method

In spite of being a numerical method the F.E.M. is taken apart from the other numerical methods with the aim of giving it special attention.

This subject is taught in 70 hours, from which 18 are dedicated to F.E.M., parcelled out in 6 hours in lectures, 8 in practical classes and 4 in laboratories.

The theme is composed of the following topics:

- FEM introduction. Brief historical development. Elasticity theory introduction. FEM generalities. Principle of virtual displacements. Nodal forces and nodal displacements. Elemental equilibrium equation. Unidimensional elements. Stiffness matrix.

Two dimensional elements. Modelling notions through FEM. Application of computational professional programs.

It is intended that through practical classes and laboratory practices the following abilities will be attained by the students:

- To solve simple problems of deformational and tensional analysis, and to check the results with those reached by the classical methods of strength materials.
- To solve simple problems of plane tensional state from a portico or carcass making use of computational professional programs of FEM.

Mechanical engineering

In this speciality the method is not among the topics that are recommended by the National Commission of Specialists, but for some courses now, the subject Strength of materials has been a part of deformational and tensional analysis of structural elements. At present the theme is taught in 8 hours and its principal parts, parcelled out in lectures and practical classes, is the following:

FEM brief historical development. FEM theoretical foundations. Introduction of the stiffness matrix.

Determination of stress and deformation of elements subjected to traction, bending and torsion through the FEM. Analysis of computational professional programs for the FEM solution.

Link between FEM and other disciplines or subjects of the speciality

Civil engineering

The FEM can be used in each subject where deformational and tensional analysis appears.

Besides, in civil engineering the inclusion of FEM is important because it establishes the continuity inside the integrating disciplines and the project is developed in correspondence with them, also the FEM is used in students thesis. For this reasons it is necessary to keep a growing knowledge of this techniques among the professors of the civil engineering faculty.

Mechanical engineering

In the case of mechanical engineering a first step has been conceived, where entailment with the subject of the discipline Applied Mechanics and the practical of the students, is carried out in this step, the FEM is entailed too, with some projects of mechanical engineering, where it is needed.

In a second step, the method will be included in subjects of thermal power processes and subjects of technological processes, as in civil engineering, to go on with its application in the student's thesis.

Postgraduate teaching

The FEM teaching at the postgraduate level has a different connotation for the following reasons :

- The professionals have been graduated through a wide variety of curricula in the specialization, as many years of graduation.
- The necessities in agreement with the speciality.

So, a different program, from the one for the undergraduate level has been elaborated. In this program , Matrix algebra, Strength of materials and Elasticity theory are reviewed. before the beginning of FEM. Each program has been made in agreement with the objectives that must be attained. On account of the real situation, three models of postgraduate courses have been elaborated.

- Inner postgraduate courses focused on the university professors for which this knowledge is necessary.
- Inside the postgraduate course on Mechanical design, a theme of FEM is treated in order to update the professor's knowledge.
- A postgraduate course has been designed where the practical side of the method receives special attention. This course is aimed at all professionals of the state, that want to be in touch with science development.

Conclusions and recommendations

A deep study through up to date bibliography and intercourse with other national and foreign universities of FEM techniques has been carried out in order to achieve its introduction in engineering courses.

From the study, we can see deeper knowledge about the theoretical aspect of FEM is necessary for students as well as professionals, aimed to make possible an efficient use of computational professionals programs.

We are recommending here FEM introduction, in works entailed to the industry, carried out by students and professors, whenever possible in order, to be able to answer the modern design industry.

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In my country we use the first and middle names, for example, in this situation my name and the others are in the following form: Elsa Napoles, Ramon Blanco, Yoanka Mc. Pherson, Rafael Jimenez. For that reason I would like our names to be recorded using the first and middle names as on the release form.